The Eastern Outlet of Valles Marineris: A Window into the Ancient Geologic and Hydrologic Evolution of Mars

Abstract #1054

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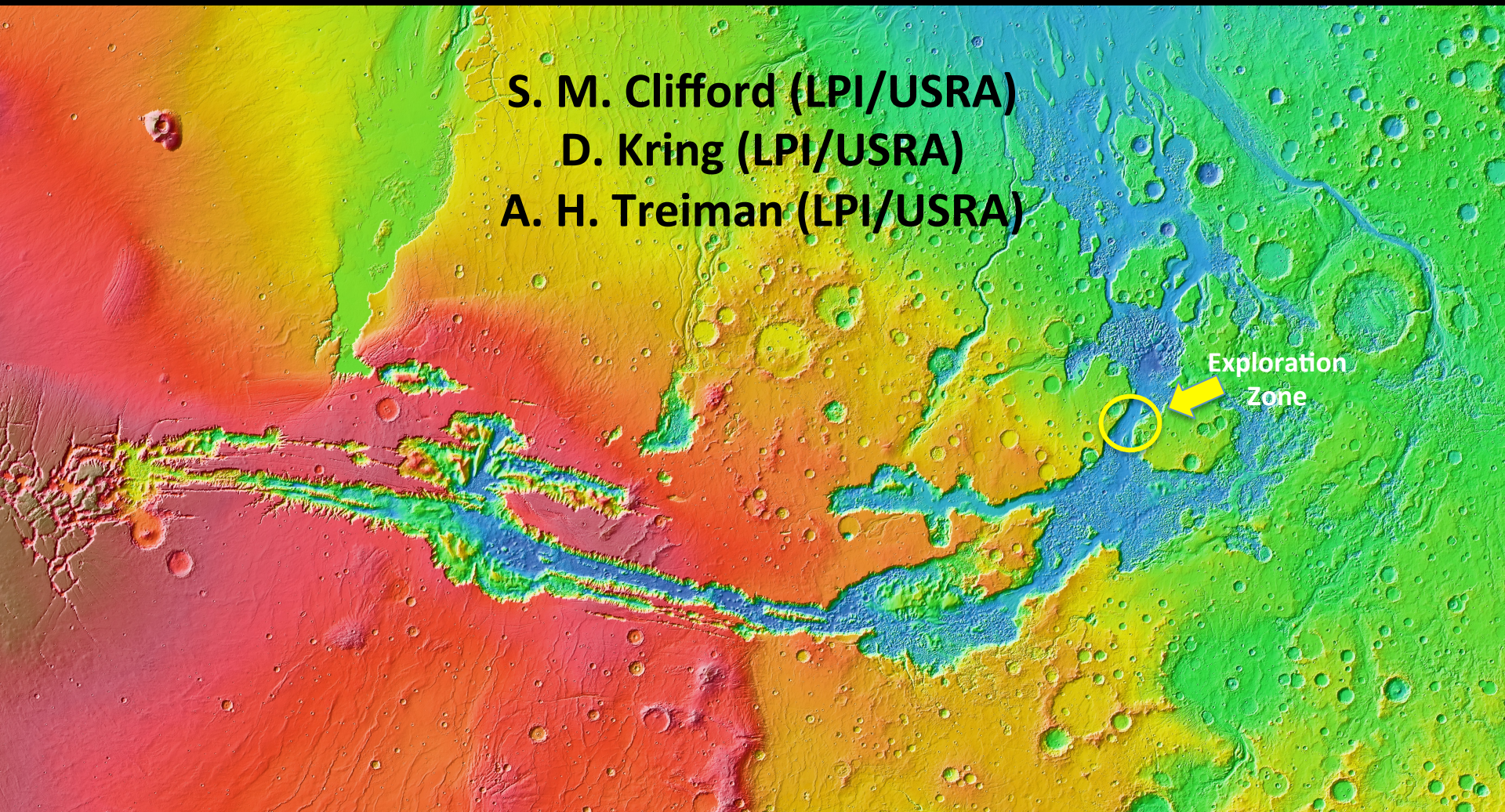
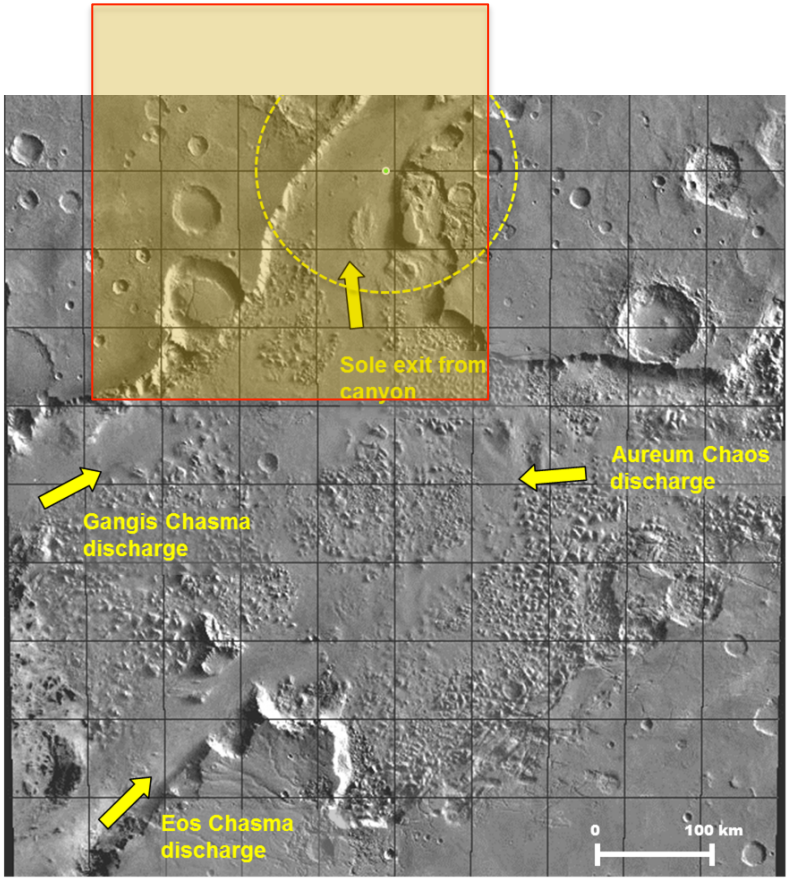


Geologic Context of Exploration Zone



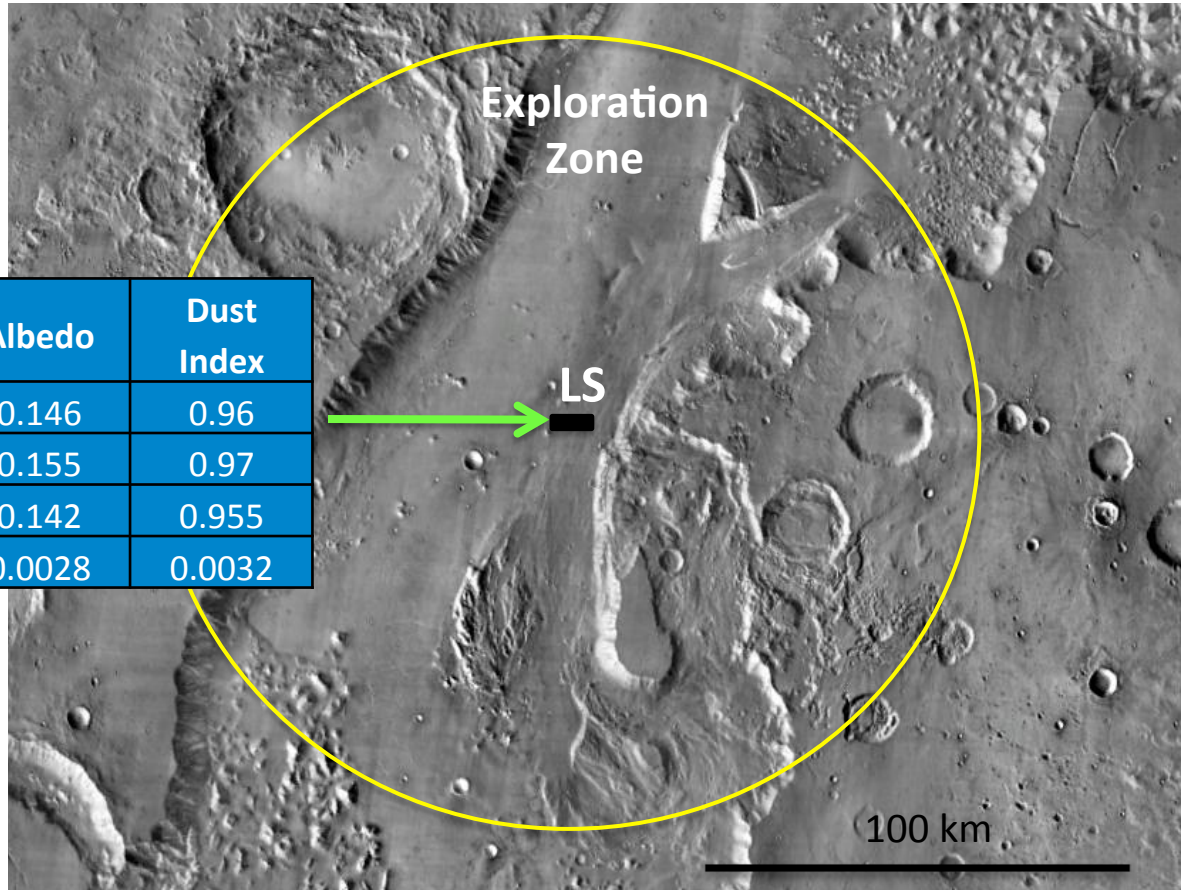
Witbeck et al. (1991). Geologic map of the Valles Marineris region, Mars (No. 2010).

Eastern Outlet of Valles Marineris

Landing Site Surface Properties

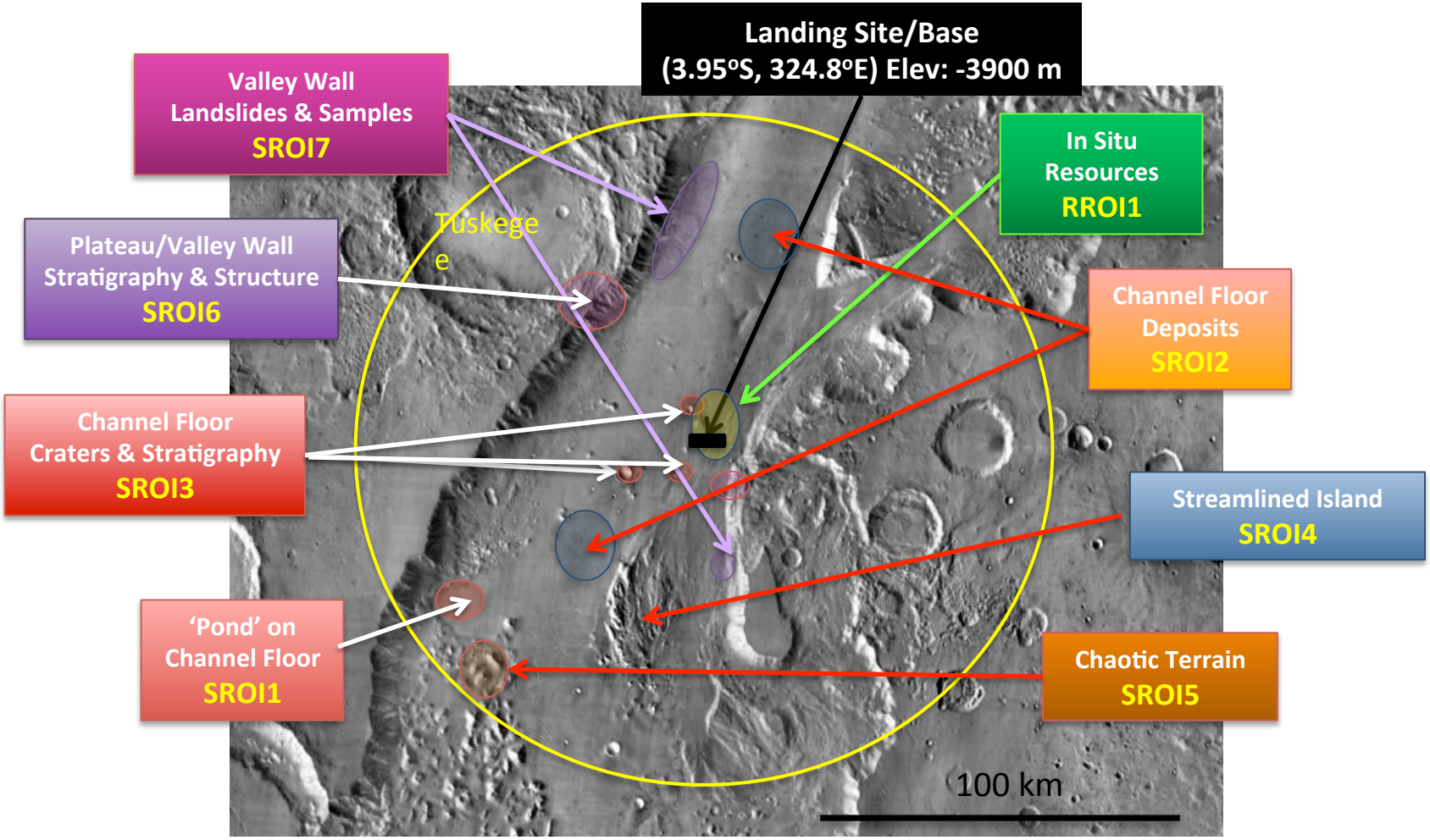
(3.95°S, 324.8°E)

	Elevation (m)	Thermal Inertia	Albedo	Dust Index
Average:	-3967	377	0.146	0.96
Maximum:	-3474	412	0.155	0.97
Minimum:	-4101	344	0.142	0.955
StDev:	76.9	1.86	0.0028	0.0032



Eastern Outlet of Valles Marineris

ROI's in Exploration Zone



Eastern Outlet of Valles Marineris

Science ROI(s) Rubric

1st EZ Workshop for Human Missions to Mars

Science Site Criteria				Site Factors	SROI1	SROI2	SROI3	SROI4	SROI5	SROI6	SROI7	RROI1	EZ SUM
	Astrobio	Threshold	AND/OR	Potential for past habitability	●	●	●	●	●	●	●	●	(8,0)
				Potential for present habitability/refugia	?	?	?	?	?	?	?	?	(0,0)
		Qualifying		Potential for organic matter, w/ surface exposure	?	?	?	?	?	?	?	?	(0,0)
	Atmospheric Science	Threshold		Noachian/Hesperian rocks w/ trapped atmospheric gases	●	●	●	●	●	●	●	●	(8,0)
		Qualifying		Meteorological diversity in space and time	●	●	●	●	●	●	●	●	(8,0)
				High likelihood of surface-atmosphere exchange	●	●	●	●	●	●	●	●	(8,0)
				Amazonian subsurface or high-latitude ice or sediment									(0,0)
				High likelihood of active trace gas sources	?	?	?	?	?	?	?	?	(0,0)
	Geoscience	Threshold		Range of martian geologic time; datable surfaces	●	●	●	●	●	●	●	●	(8,0)
				Evidence of aqueous processes	●	●	●	●	●	●	●	●	(8,0)
				Potential for interpreting relative ages	●	●	●	●	●	●	●	●	(8,0)
		Qualifying		Igneous Rocks tied to 1+ provinces or different times	●	●	●	●	●	●	●	●	(8,0)
				Near-surface ice, glacial or permafrost									(0,0)
				Noachian or pre-Noachian bedrock units	?	?	●	●	●	●	●	?	(5,0)
				Outcrops with remnant magnetization	●	●	●	●	●	●	●	●	(8,0)
				Primary, secondary, and basin-forming impact deposits	●	●	●	●	●	●	●	●	(8,0)
				Structural features with regional or global context	●	●	●	●	●	●	●	●	(8,0)
				Diversity of aeolian sediments and/or landforms	?	●	?	?	?	?	?	●	(2,0)

ROI Descriptions:

SROI1: 'Pond' on Channel Floor

SROI2: Channel Floor Deposits

SROI3: Channel Floor Craters & Stratigraphy

SROI4: Streamlined Island

SROI5: Chaotic Terrain

SROI6: Plateau/Valley Wall Stratigraphy & Structure

SROI7: Valley Wall Landslides & Samples

RROI1: In-Situ Resources

Key	
●	Yes
○	Partial Support or Debated
	No
?	Indeterminate

Eastern Outlet of Valles Marineris

Resource ROI(s) Rubric

1st EZ Workshop for Human Missions to Mars

				Site Factors	SROI1	SROI2	SROI3	SROI4	SROI5	SROI6	SROI7	RROI1	EZ SUM
ISRU and Civil Engineering Criteria	Engineering			Meets First Order Criteria (Latitude, Elevation, Thermal Inertia)	●	●	●	●	●	●	●	●	(8,0)
	Water Resource	Threshold	AND/OR	**Potential for ice or ice/regolith mix**	?	?	?	?	?	?	?	?	(0,0)
				Potential for hydrated minerals	●	●	●	●	●	●	●	●	(8,0)
				Quantity for substantial production	?	?	?	?	?	?	?	?	(0,0)
				Potential to be minable by highly automated systems	?	?	?	?	?	?	?	?	(0,0)
				Located less than 3 km from processing equipment site		●							(1,0)
				Located no more than 3 meters below the surface	?	?	?	?	?	?	?	?	(0,0)
				Accessible by automated systems	●	●	●	●	●	●	●	●	(8,0)
		Qualifying		Potential for multiple sources of ice, ice/regolith mix **and** hydrated minerals	?	?	?	?	?	?	?	?	(0,0)
				Distance to resource location can be >5 km	●	●	●	●	●	●	●	●	(8,0)
				Route to resource location must be (plausibly) traversable	●	●	●	●	●	●	●	●	(8,0)
	Civil Engineering	Threshold		**~50 sq km region of flat and stable terrain with sparse rock distribution**	●	●	●	●	●	●	●	●	(8,0)
				1–10 km length scale: <10°	●	●	●	●	●	●	●	●	(8,0)
				Located within 5 km of landing site location		●							(1,0)
		Qualifying		Located in the northern hemisphere									(0,0)
				Evidence of abundant cobble sized or smaller rocks and bulk, loose regolith	●	●	●	●	●		●	●	(7,0)
				Utilitarian terrain features		●	●	●	●	●	●		(6,0)
	Food Production	Qualifying		Low latitude	●	●	●	●	●	●	●	●	(8,0)
				No local terrain feature(s) that could shadow light collection facilities	●	●	●	●	●	●	●	●	(8,0)
													(0,0)
				Access to water	?	?	?	?	?	?	?	?	(0,0)
				Access to dark, minimally altered basaltic sands		?	?	?	?	?	?	?	(0,0)
	Metal/Silicon Resource	Threshold		**Potential for metal/silicon**	?	?	?	?	?	?	?	?	(0,0)
				Potential to be minable by highly automated systems	?	?	?	?	?	?	?	?	(0,0)
				Located less than 3 km from processing equipment site	?	?	?	?	?	?	?	?	(0,0)
				Located no more than 3 meters below the surface	?	?	?	?	?	?	?	?	(0,0)
				Accessible by automated systems	?	?	?	?	?	?	?	?	(0,0)
		Qualifying		Potential for multiple sources of metals/silicon	?	?	?	?	?	?	?	?	(0,0)
				Distance to resource location can be >5 km	●	●	●	●	●	●	●	●	(8,0)
				Route to resource location must be (plausibly) traversable	●	●	●	●	●	●	●	●	(8,0)

ROI Descriptions:

SROI1: 'Pond' on Channel Floor

SROI2: Channel Floor Deposits

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SROI5: Chaotic Terrain

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SROI7: Valley Wall Landslides & Samples

RROI1: In-Situ Resources

Key	
●	Yes
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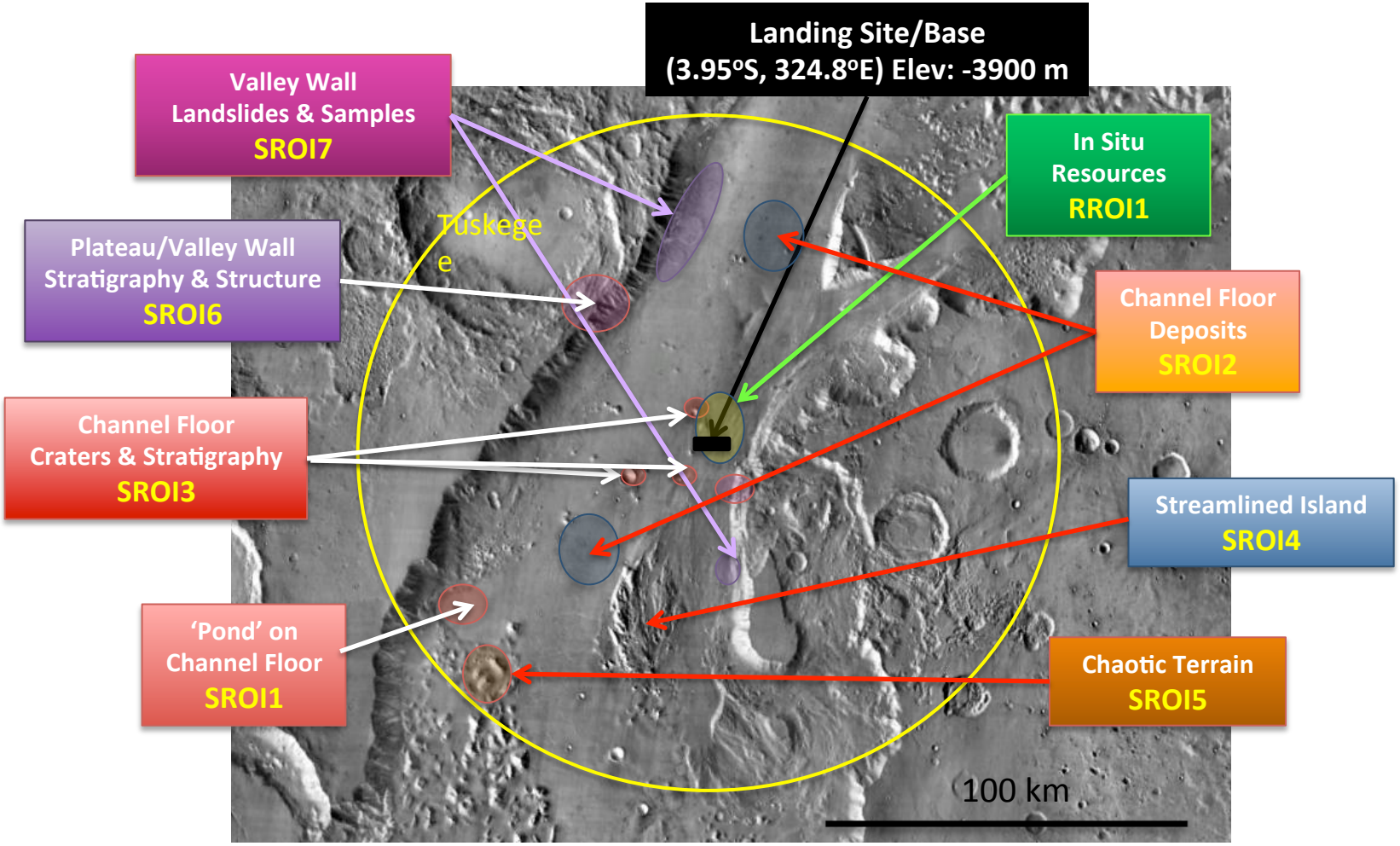
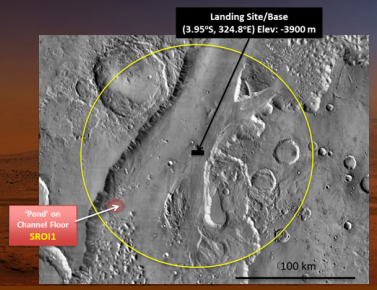
	No
?	Indeterminate

Eastern Outlet of Valles Marineris

Exploration Zone Map



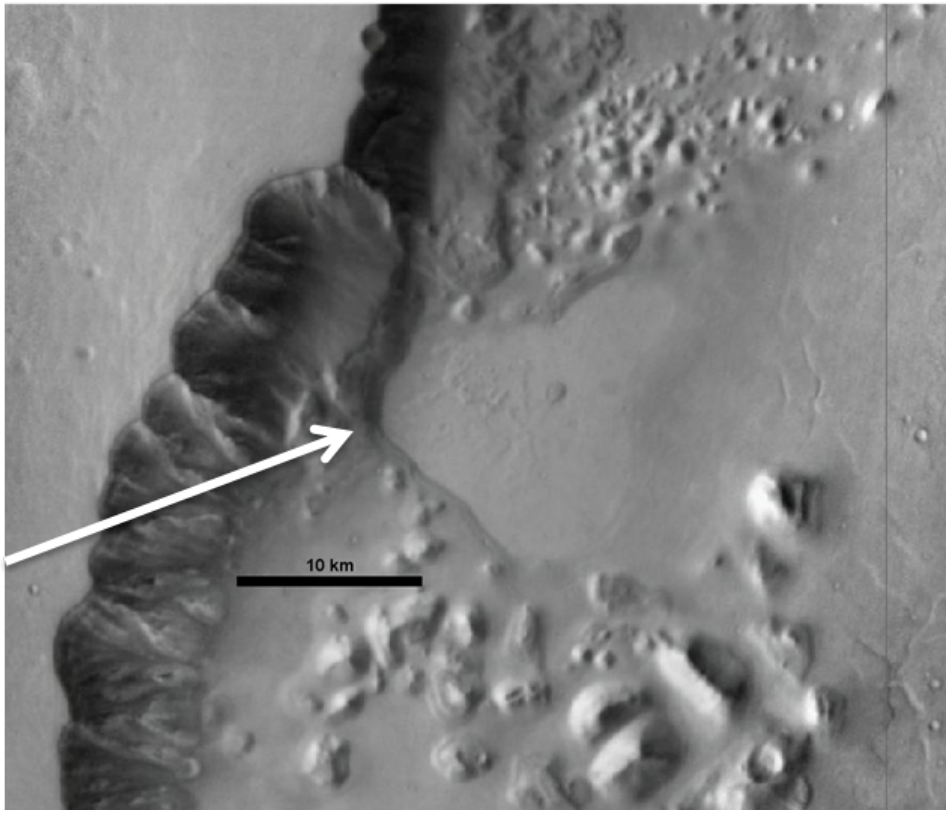
Eastern Outlet of Valles Marineris



Science ROI 1: 'Pond' on Channel Floor

(4.57°S, 323.67°E) Elev: -4185 m

- In the SW quadrant of the EZ, lies an ~13 km diameter deposit of light-toned material that fills a local depression, in close proximity to an extensive area of chaotic terrain.

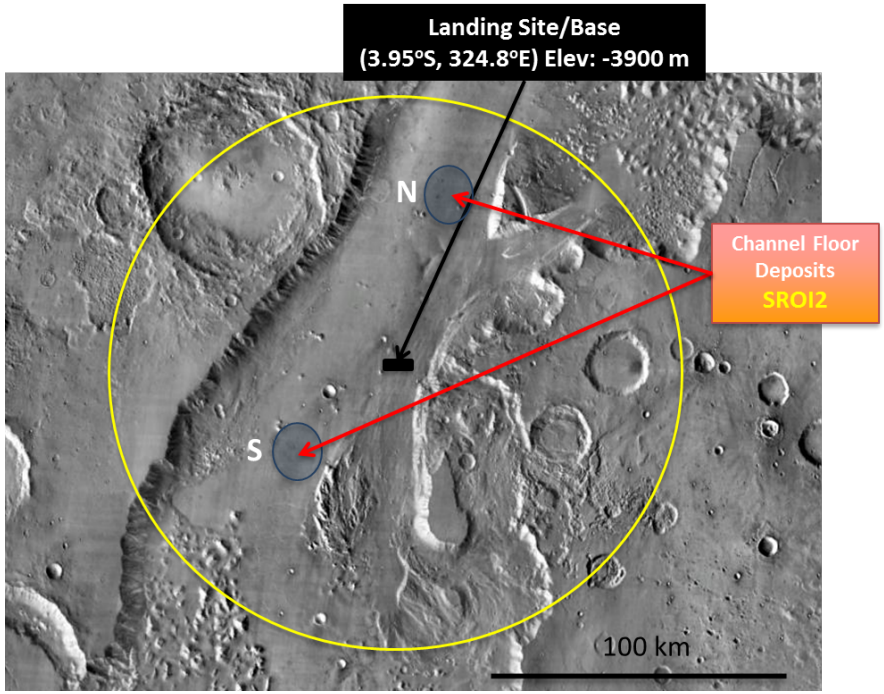


- Valles Marineris exhibits extensive of recurrent episodes of massive fluvial discharge >3 Ga-old, emanating from Aurorae Chaos, Aureum Chaos, and other regions to the west. These discharges would have ponded in the ~10^5 km^2 topographic depression, that lies just before the eastern outlet of Valles Marineris, before spilling into Chryse Planitia.
- The location of SROI1 is consistent with an episodic fluvial and lacustrine environment that may preserve a sedimentary record of these ancient discharges, as well as the organic remnants of early Martian life.
- Available imaging: HRSC, THEMIS

Eastern Outlet of Valles Marineris

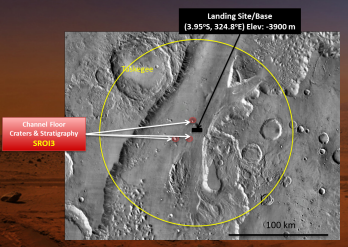
Science ROI 2:
Channel Floor Deposits

Elev: -4250 m (EZ-S) to -4030 m (EZ-N)

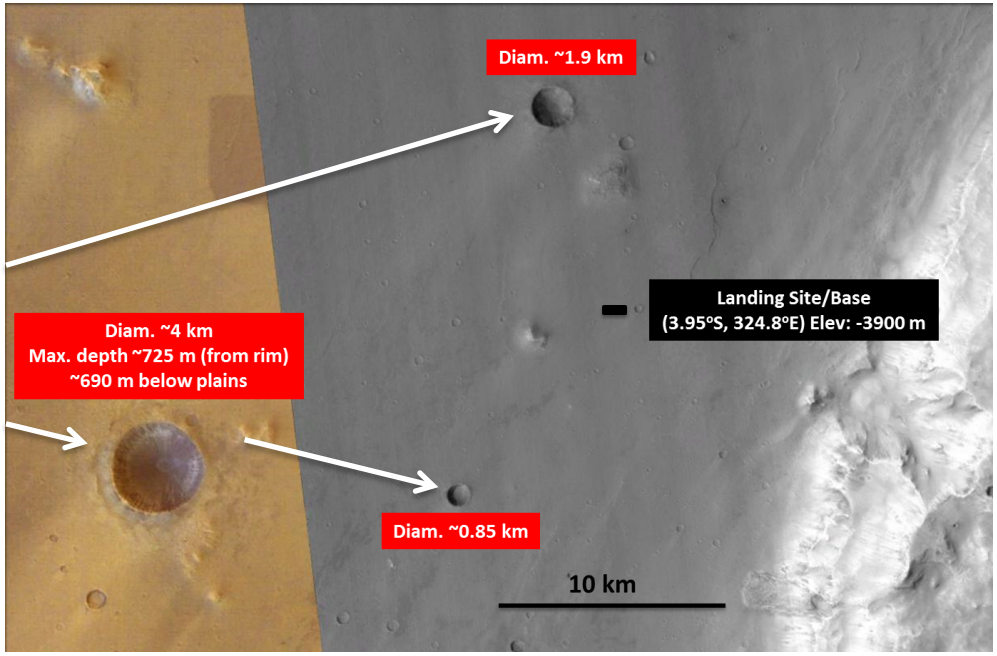


- The eastern outlet of Valles Marineris is drained by a channel only ~50-75 km-wide -- and represents the sole pathway by which water (discharged from canyon lakes and extensive regions of chaotic terrain) could have reached the northern plains. Similar to SROI1, the channel floor deposits will provide numerous and diverse targets for geologic and astrobiological investigations of Noachian- and Hesperian-age fluvial activity, volcanism, and more recent eolian erosion and sedimentation.
- Because these deposits are found throughout the ~200 km length of the channel floor, they are readily accessible, without the need for extended traverses.
- Available imaging: HRSC, THEMIS, CTX, HiRISE.

Eastern Outlet of Valles Marineris



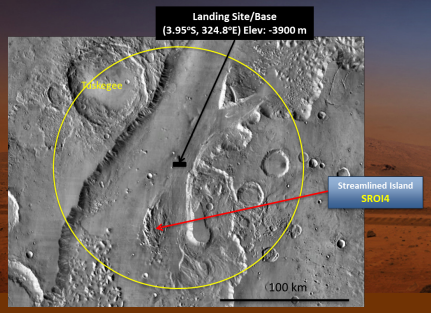
Science ROI 3:
Channel Floor Craters & Stratigraphy
(3.95°S, 324.6°E) Elev: -4065 m



Impact craters, ranging from meters to several kilometers in diameter, are found throughout the channel floor – with several of the largest lying within 30-km of the proposed landing site.

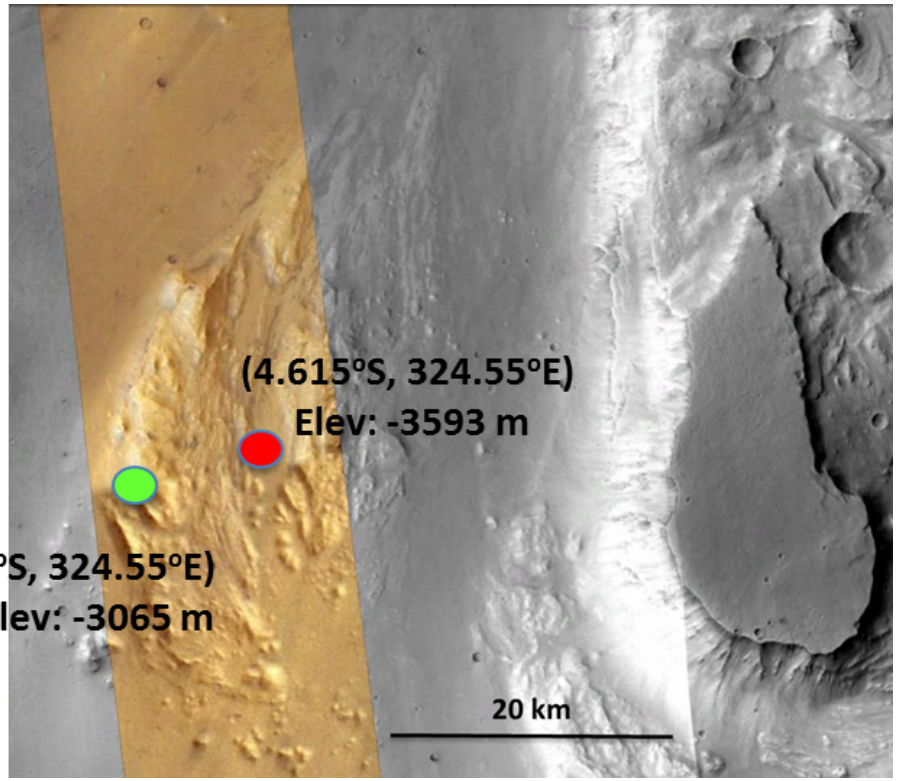
- Investigation of the geologic and fluvial history of the channel is aided by the presence of sub-kilometer to ~4 km-diameter impact craters whose interiors may provide access for observing and sampling the channel's stratigraphic record down to a depth of ~700 m.
- Ground Penetrating Radar (GPR) and shallow-drilling investigations could extend this understanding of subsurface stratigraphy and structure between craters, throughout the channel's length.
- Available imaging: HRSC, THEMIS, CTX, HiRISE.

Eastern Outlet of Valles Marineris



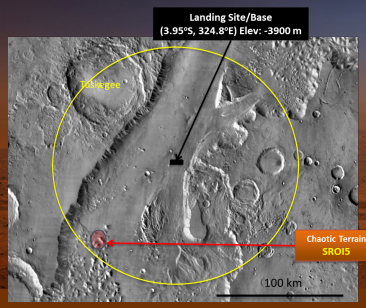
Science ROI 4: Streamlined Island

(4.615°S, 324.55°E) Elev: -3593 m



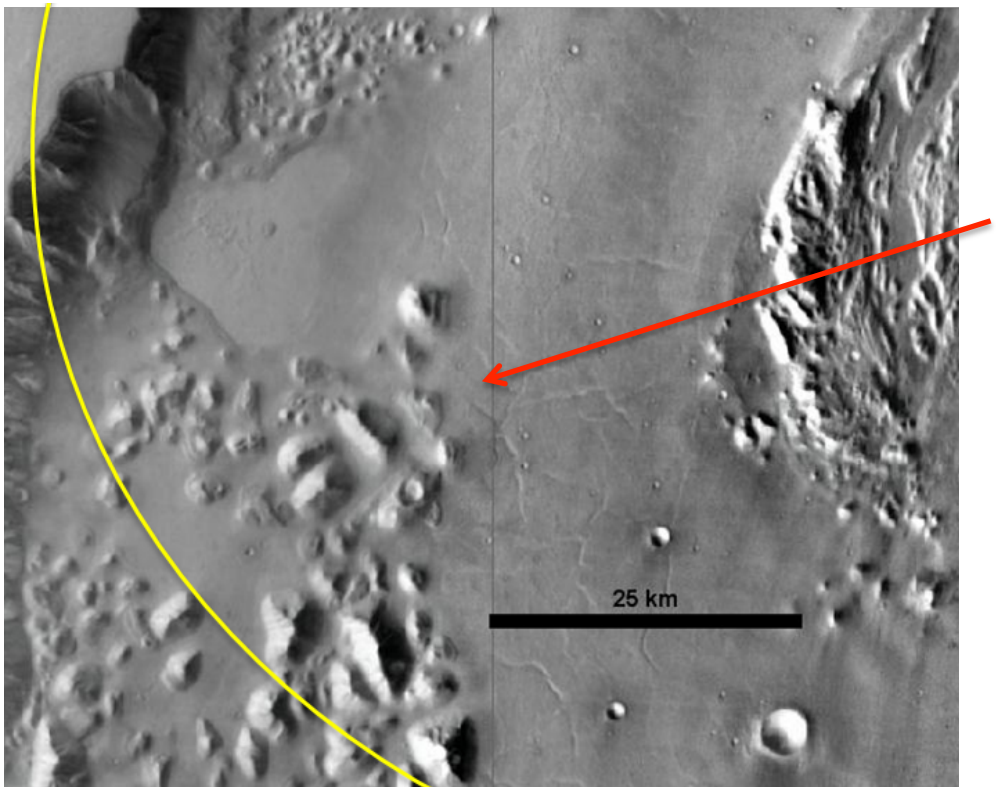
- Streamlined islands are believed to form by catastrophic floods, which can erode 100's of m of rock and sediment in hours to days.
- Evidence of the catastrophic nature of the outflow event that carved SROI4 can be see in the plateau on the right, where water, entering the eastern outlet of VM, overtopped the plateau and carved a perched channel that recombined with the main channels a few 10's of km downstream.
- The original nature of the streamlined island is unknown. It may consist of erosionally resistant Noachian bedrock, or it may by the product of an earlier episode of fluvial deposition that was subsequently eroded by a later and larger discharge.
- The total vertical relief of the ~40 km long island is ~520 m abover the surrounding channel floor
- Available imaging: HRSC, THEMIS, CTX, HiRISE.

Eastern Outlet of Valles Marineris



Science ROI 5: Chaotic Terrain

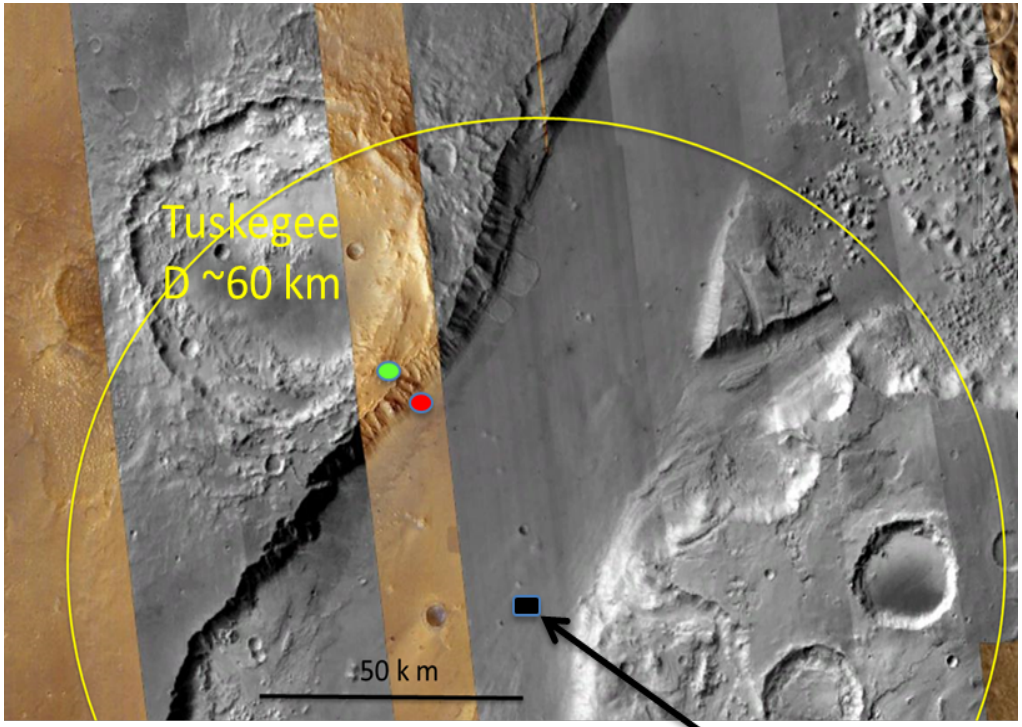
(4.89°S, 323.83°E) Elev: -3811 m



- Chaotic terrain, which consists of jumbled blocks of crustal rocks, which are thought to result from the catastrophic discharge of groundwater, confined by a thick layer of ice-rich permafrost, under significant hydraulic head.
- Such events may be initiated when the hydraulic confinement of a subpermafrost aquifer is breached by an impact, earthquake, the destabilization of gas hydrate, or a magmatic intrusion.
- The presence of chaotic terrain at several locations within the Exploration Zone may aid the identification of the responsible triggering mechanism by geologic mapping, geophysical investigations and sample analysis.
- Available imaging: HRSC, THEMIS, CTX, HiRISE.

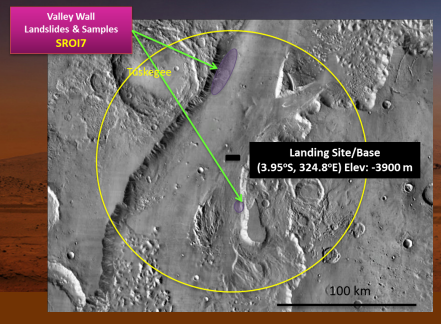
Science ROI 6:
Plateau/Valley Wall Stratigraphy & Structure

(3.27°S, 324.48°E) Base of Scarp -3948 m, Plateau: -641 m



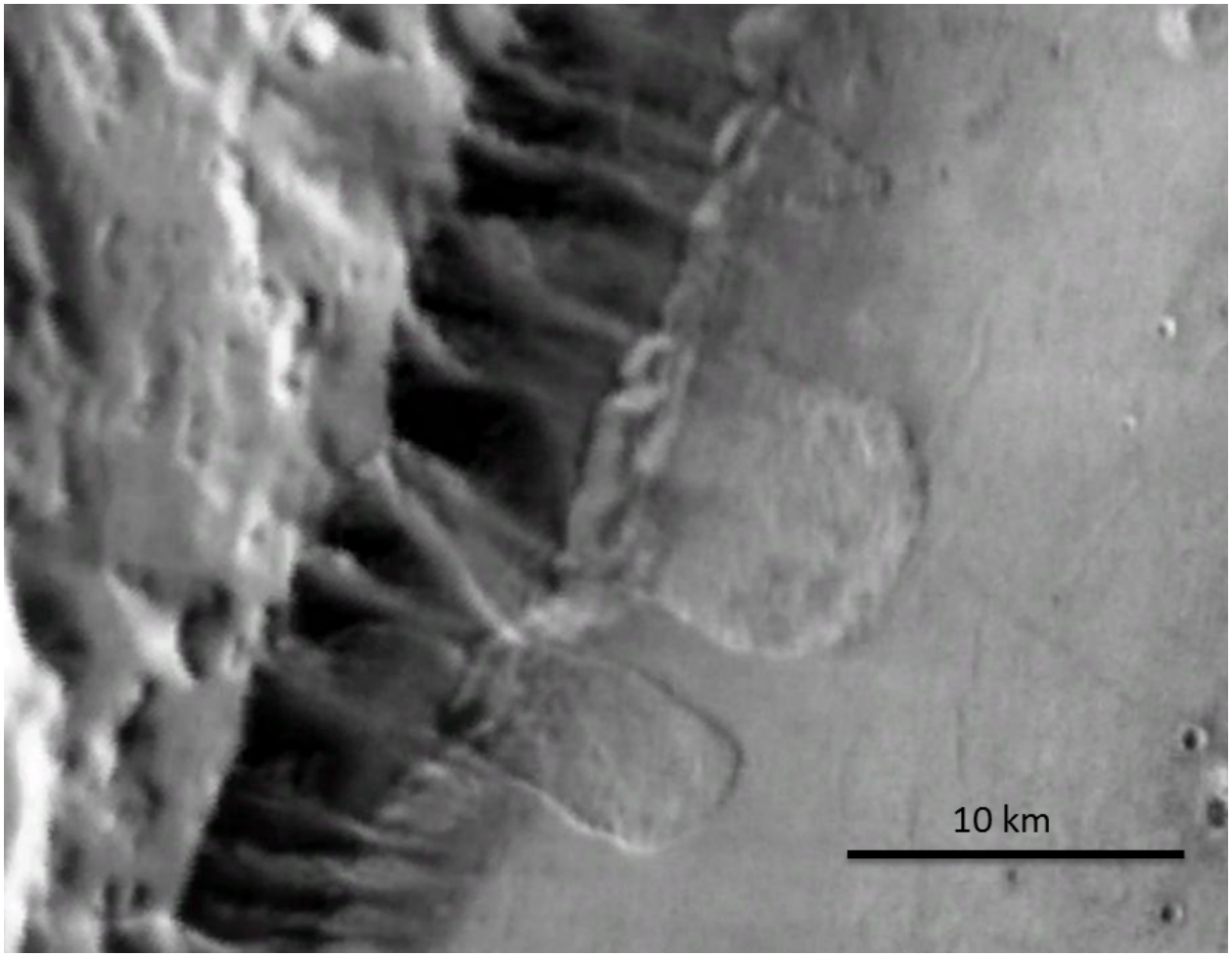
Eastern Outlet of Valles Marineris

- The fluvial discharges that carved the eastern outlet of Valles Marineris incised several km of Noachian plateau material that predate the end of valley network formation – exposing some of the oldest rocks accessible anywhere on the planet. These rocks are preserved in their original geologic and may contains clues regarding the composition of the early Martian atmosphere and natures of the early climate.
- These rocks may also contain clays and other alteration products that preserve the signature of early life.
- One of the best locations for investigating this ancient stratigraphy is the northern valley wall, near Tuskegee Crater (~60 km diam.). This ~3-3.5 km scarp will provide a look at the stratigraphy and structure of the early crust – and how it was modified by large impacts (by brecciation, magmatic and hydrothermal activity)
- In addition to spectroscopic and imaging studies,conducted from the valley floor, it may be possible to directly sample wall rock through the use of cliffbots or by retrieving samples from landsides. Three large landslides occur in close proximity to Tuskegee several 10's of km further up the northern wall.
- Available imaging: HRSC, THEMIS, CTX, HiRISE...



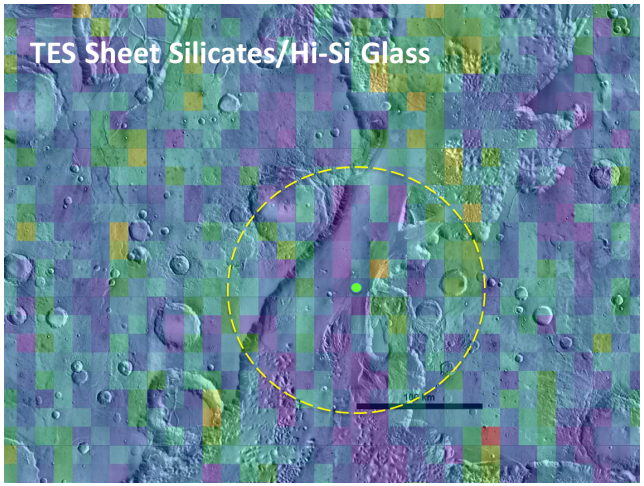
Science ROI 7:
Valley Wall Landslides & Samples

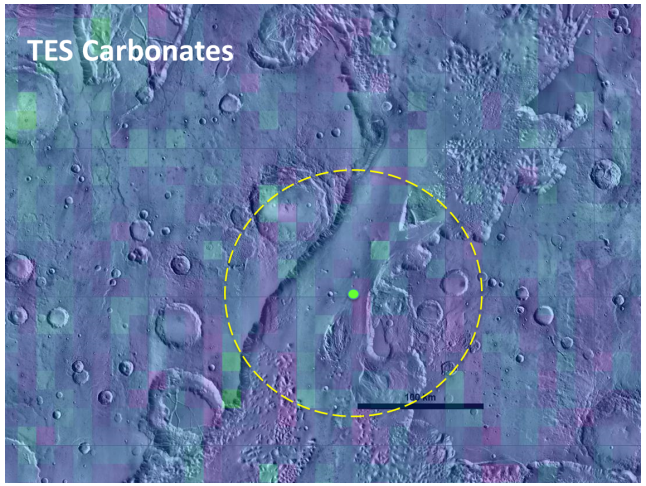
(2.85°S, 324.82°E) Elev: -4075 m

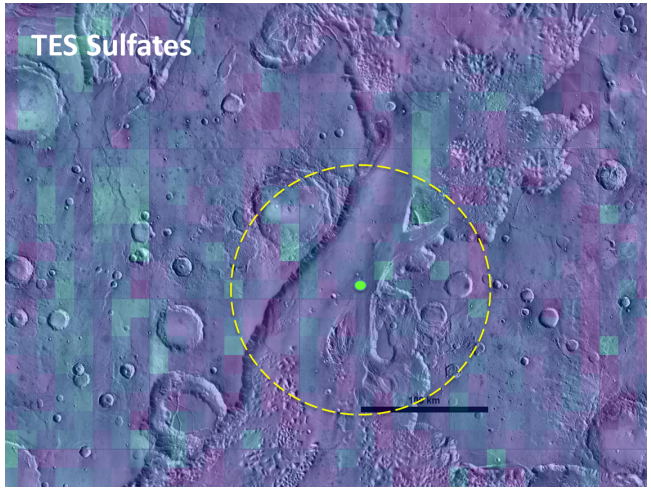


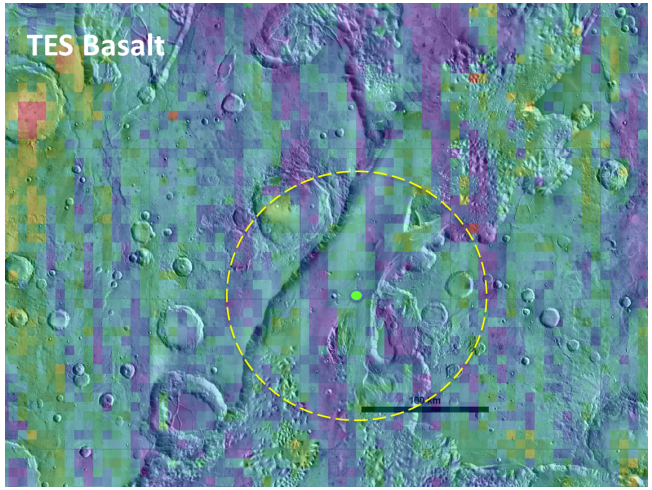
Eastern Outlet of Valles Marineris

Resource ROI 1: In-Situ Resources









Bandfield, J. L. (2002). Global mineral distributions on Mars. *Journal of Geophysical Research: Planets (1991–2012)*, *107*(E6), 9-1.

Eastern Outlet of Valles Marineris

Highest Priority EZ Data Needs

Single most important additional data set needed to assess the science and resource potential of the EZ?

- Orbiter:
  - High-Resolution Synthetic Aperture Radar (full coverage spatial, at multiple times per day): Detection of persistent or recurring brines/special regions, determination of near-surface permittivity (potentially indicative of high-porosity or ice content) and investigation of near-subsurface structure (top few m to tens of m, depending on frequency).
- Rover:
  - Mars 2020/ExoMars-class rover reconnaissance of proposed landing site (including GPR and shallow-drilling): Survey for surface and subsurface hazards, soil properties, and in-situ resources.

Eastern Outlet of Valles Marineris

Prioritization List of EZ Data Needs
(Needed assets: Existing/Future)

- Data to be collected to assess the science potential of the EZ:
  - Orbiter:
    1. HiRISE (full coverage): Presence of RSL and other geologic evidence of past/present climate, water, ice, and habitability.
    2. CRISM (full coverage): Mineralogical evidence of past/present climate, water, ice, and habitability.
    3. High-Resolution Synthetic Aperture Radar (full coverage spatial, at multiple times per day): Detection of persistent or recurring brines/special regions, determination of near-surface permittivity (potentially indicative of high-porosity or ice content) and investigation of near-subsurface structure (top few m).
- Data to be collected to assess the resource potential of the EZ:
  - Orbiter:
    1. HiRISE (full coverage): Presence of RSL, landing and mobility hazard assessment.
    2. CRISM (full coverage): Inventory of available mineralogical resources.
    3. High-Resolution Synthetic Aperture Radar (full coverage spatial, at multiple times per day): Determination of near-surface permittivity (potentially indicative of high-porosity or ice content) and investigation of near-subsurface structure (top few m).
  - Rover:
    1. Mars 2020/ExoMars-class rover investigation of proposed landing site (including GPR and shallow-drilling): Survey for surface and subsurface hazards, soil properties, and in-situ resources.

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